Geographic Variation of Longevity in Ohio, 1930 and 1980[1]

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ABSTRACT. At broad levels (i.e., urban and rural, north and south, state-by-state), variations in longevity have been recorded over time in the United States and elsewhere. However, there is little information on life expectancy variation for specific "small areas" such as cities and suburbs over time. This is understandable because life expectancy is usually calculated by constructing a life table which has rigorous requirements not usually met by published data for small areas. In this paper, we use a regression-based technique to estimate life expectancy in 1930 and 1980 for selected cities and their suburbs as well as rural counties in Ohio. We examine the variation and changes in life expectancy through multivariate analysis, and find that while differences have narrowed between 1930 and 1980, significant variations in longevity persist among suburban, urban, and rural areas in Ohio.

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INTRODUCTION

It has been well documented that substantial variations in longevity exist among the broad geographic divisions within the United States (US), as well as among individual states (Dublin et al. 1949, Glover 1921, Grove and Hetzel 1968, US Department of Health, Education, and Welfare [USDHEW] 1975). Populations in rural areas have consistently exhibited longer life expectancy than urban populations (Condran and Crimmins 1980, Dublin et al. 1949, Glover 1921). In addition, substantial increases in life expectancy have been recorded for Ohio between 1930 and 1980, and for other states and the nation as a whole (Grove and Hetzel 1968, US Department of Health and Human Services [USDHHS] 1985).

Virtually no information is available, however, on changes in life expectancy over a long period for populations in a set of specific cities, suburbs, and rural areas. This gap in our knowledge exists because the usual way to calculate life expectancy is through the construction of a life table, which has rigorous data requirements that are difficult to meet for specific sub-state areas over time (Shryock et al. 1976). This is unfortunate because it has been difficult to identify small area geographic mortality differentials that are free from the confounding effects of varying age distributions (Linder and Grove 1943). It is also unfortunate because life expectancy is an important indicator for health planning, which is generally accomplished in the United States at sub-state levels. Readily available longevity data for small areas would help in fulfilling planning information requirements, especially for health programs associated with the aged (Feinleib 1984, National Center for Health Statistics [NCHS] 1984, Soldo and Manton 1985, Wennberg and Gittelsohn 1975, 1980).

In this paper, we examine life expectancy in 1930 and 1980 for populations in specific Ohio cities and their suburbs, as well as rural counties. This study serves two major purposes: (1) to determine if significant variations in longevity exist among these areas, and (2) to determine if increases in longevity documented for Ohio between 1930 and 1980 occurred uniformly for suburban, urban, and rural areas within the state.

The life expectancy figures are available because of a regression-based estimation technique developed by Mazur (1969a, 1969b, 1971, 1972) and refined by Swanson and Palmore (1976), Swanson et al. (1977), and Gunasekaran et al. (1981). This technique produces accurate life expectancy values at birth ($\overset{o}{e}_o$) for national populations worldwide (Swanson and Palmore 1976, Swanson et al. 1977), but its use to-date has been confined primarily to demographers working with incomplete data from developing countries (Gunasekaran et al. 1981, Ogawa and Suits 1981, and Palmore 1978). Consequently, its utility for estimating $\overset{o}{e}_o$ for "small areas" in developed countries has been overlooked.

METHODS

The usual way to obtain a life expectancy figure is to construct a life table. This minimally requires: (1) accurate figures on death by age for a given period; and (2) accurate figures on the population by age for the same period. In regard to deaths by age, it has long been a practice in the United States to record both age at death and residence of a decedent on the death certificate. Hence, in principle, age-specific death data are available for any given area. However, because of the cost of tabulation and printing, information on age-specific deaths for many sub-state areas is not provided in official mortality reports (e.g., USDHHS 1980, U.S. Bureau of the Census 1930). Similarly, the same lack of geographic detail in printed census reports constrains the ability to fulfill the second data requirement for constructing a life table.

The technique used to estimate life expectancy requires only two data items, both of which are available from published sources for a greater level of geographic detail than complete age-specific deaths and the complete age distribution of a population. The two items are: (1) the crude death rate; and (2) the percent of the population age 65 years and over. These two items were used in the following equation to estimate life expectancy at birth (Swanson and Palmore 1976):

$$\overset{o}{e}_o = (1000)/[(13.02763) + (0.32011M - 0.2007^{*}M^{*} \log_{10} P65+)^2],$$

where

$\overset{o}{e}_o$ is the life expectancy at birth;

M is the crude death rate; and

P65+ is the percent of the population aged 65 years and over.

The reason why this equation provides accurate estimates of $\overset{o}{e}_o$ is that the percent of the population aged 65 years and over increases exponentially as a function of relative mortality. Further, as mathematically proven by Swanson et al. (1977), the index used to measure relative mortality that is implicitly found in the equation is an index of population aging. Given this index and its exponential relationship with the percent of the population aged 65 years and over, the relationship of P65+ with $\overset{o}{e}_o$ is logarithmic in a regression model.

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One source of random error that can affect the accuracy of $\overset{o}{e}_o$ estimates generated by this method is the stochastic variability of death rates for the population of a small area (Manton and Stallard 1981). However, the estimation equation is less sensitive to this source of error than is an $\overset{o}{e}_o$ value calculated by constructing a life table. The life table requires age-specific deaths; the estimation equation requires only total deaths.

A procedure often used to dampen the effects of stochastic variability on small area death rates is to take a multi-year average of deaths centered on the year for which population (the denominator in a death rate) data are available. However, except under very limited conditions, such an average is biased with respect to its estimated death rate as has been shown by Palit and Krebs (1977). Thus, unbiased alternatives to using death data for a single year must involve weighted multi-year averages or an autoregressive model (Palit and Krebs 1977). These alternatives introduce a level of complexity that is not needed, since Swanson and Swanson (1978) found that the estimation equation is robust with respect to random errors.

Although there are several potential restrictions on the use of this equation to estimate life expectancy, depending on the overall age composition of a population and the level of its crude death rate, the results presented here were not affected by them. A test developed by Swanson and Palmore (1976) was used to determine the suitability of the equation. A complete discussion of the test is given by Swanson and Palmore (1976). Similarly, other potential restrictions pertaining to the completeness of death registration and census enumerations that may be encountered in less developed countries also do not apply in the present case.

Following the development of the life expectancy information a series of statistical tests were used to determine if there were significant differences in $\overset{o}{e}_o$ among suburban, urban, and rural areas both in 1930 and in 1980. First, separate regression models for 1930 and 1980 were constructed in which $\overset{o}{e}_o$ was the dependent variable, and the independent variables were dummy variables representing "suburb" and "rural county," allowing "city" to be the reference category (SPSS 1970). Changes in $\overset{o}{e}_o$ between 1930 and 1980 were tested for significant differences in geographical effects with the Chow Test (Chow 1960, Fisher 1970).

RESULTS AND DISCUSSION

LIFE EXPECTANCY ESTIMATES. In Table 1, we give estimates of life expectancy at birth in 1930 and 1980 for selected Ohio cities and their suburban areas. The eight cities are those that had a population of at least 75,000 in 1930 and 1980. These cities and their suburbs represent a consistent set for purposes of comparison between 1930 and 1980. The "suburb" of each of the eight cities is the "balance of county" area associated with each city. This definition may not be precise (e.g., Youngstown, is primarily in Mahoning County, but its corporate boundaries extend into Trumbull County; and Stark's "balance of county" contains Massillon); however, by using the balance of county, a consistent approximation of the suburban area of each city exists for both 1930 and 1980.

The life expectancy figures for 1930 and 1980 are provided for the rural counties of Ohio in Table 2. The 22 counties selected represent those that were not part of a standard metropolitan statistical area (SMSA) in 1980, and also did not contain a town with a population exceeding 10,000 in either 1930 or 1980.

As a means of evaluating the accuracy of the life expectancy values given in Tables 1 and 2, a comparison was made between the reported figures (Grove and Hetzel 1968, USDHEW 1975, USDHHS 1985) for each decennial census year, 1930 to 1980, and estimates derived

TABLE 2

Life Expectancy at Birth for Rural Counties In Ohio, 1930 and 1980

County	Life expectancy at birth (yrs.) 1930	1980
Adams	64	71
Brown	67	71
Gallia	53	72
Hardin	65	72
Harrison	68	71
Henry	69	73
Highland	65	72
Holmes	66	73
Jackson	63	69
Meigs	67	72
Mercer	66	71
Monroe	69	74
Morgan	59	72
Morrow	66	71
Noble	68	73
Paulding	69	71
Perry	67	71
Pike	62	72
Union	67	71
Vinton	64	72
Williams	67	72
Wyandot	65	72
Mean	65.3	71.7
Standard deviation	±3.7	±1.0

TABLE 1

Life Expectancy At Birth For Ohio's Major Cities and Their Corresponding Suburban Areas, 1930 and 1980

City	Corresponding suburban area	Life expectancy at birth (yrs.) 1930 City	1930 suburb	1980 City	1980 suburb
Akron	Balance of Summit Co.	62	67	71	72
Canton	Balance of Stark Co.	61	59	70	72
Cincinnati	Balance of Hamilton Co.	53	70	70	72
Cleveland	Balance of Cuyahoga Co.	55	68	68	72
Columbus	Balance of Franklin Co.	51	65	70	72
Dayton	Balance of Montgomery Co.	60	65	70	72
Toledo	Balance of Lucas Co.	55	67	70	72
Youngstown	Balance of Mahoning Co.	55	64	70	72
	Mean	56.5	65.6	69.9	72
	Standard Deviation	±4.0	±3.3	±0.8	0

from our equation. The reported (estimated) values for the six census years were 60(60), 63(64), 68(68), 70(69), 71(70), and 74(73), respectively.

The life expectancy values in Tables 1 and 2 can also be compared with the published crude death rates for each city, suburban area, and rural county in 1930 and 1980 (Appendix Tables 1-3). Gallia County, for example, had the highest crude death rate (19.26) of any area in 1930. However, its life expectancy (53 yrs) was not the lowest in 1930; the lowest value (51 yrs) was found for Columbus (Table 2). This change in ranking reflects the confounding effects of varying age distributions on the crude death rate. These effects were not observed when comparing values for life expectancy.

It is shown in Table 1 that the suburban area populations generally experienced higher and less variable life expectancy than the corresponding set of city populations in both 1930 and 1980. This was especially apparent for 1930. The suburban areas also had a longer life expectancy and less variability in 1980, even though the gap in both areas was considerably less than it was in 1930.

Two distinct sets of cities were found in 1930. The first was comprised of Akron, Canton, and Dayton, each of which had a population with an average life expectancy of at least 60 years at birth. The second was comprised of Cincinnati, Cleveland, Toledo, and Youngstown. None of these had a life expectancy that exceeded 55 years at birth (Table 1). The second set also contained the three largest cities in Ohio in 1930: Cincinnati, Cleveland, and Toledo. The data for these two sets of cities indicated an inverse relationship between population size and longevity, which was in accordance with the findings of other studies (Crimmins and Condran 1983, Higgs and Booth 1979) showing a positive relationship between mortality and crowding for cities in the United States around the turn of the century.

Interestingly, only one city (Canton, Ohio in 1930) exhibited a higher life expectancy than its corresponding suburban area. However, in 1980, the position of Canton and its suburban area was reversed. The suburban area life expectancy exceeded that of Canton by two years (Table 1). The reasons for this are related to the presence of Massillon in the balance of Stark County.

The surburban areas are also of interest in terms of the lower variation in life expectancy among them in both 1930 and 1980, as compared to that of the cities. In fact, there was no variation in 1980. Each suburban area had a life expectancy at birth of 72 years (Table 1).

The life expectancy figures for the rural counties were generally similar in level and trend to those of the suburban areas (Table 2). The mean values were very close for rural counties and suburban areas in 1930 and 1980, as was the increase in mean values between 1930 and 1980. Further, only Jackson County had a life expectancy of less than 71 years in 1980.

Overall, the data in Tables 1 and 2 reveal that the populations in suburban areas experience slightly higher life expectancy than the rural area populations, which in turn experience much higher life expectancy than the city populations. This ranking was especially apparent for 1930 in the difference between suburbs and rural areas on the one hand, and cities on the other. In 1980, although the gap closed, it appeared that the city populations still experienced lower life expectancy than the suburban and rural populations.

Statistical Analyses. Differences among the suburban, urban, and rural populations were analyzed statistically. The characteristics of the regression model for 1930 are provided in Table 3. The constant (56.50) provides the expected length of life at birth for the city populations in 1930. The coefficient for "suburb" indicates that 9.125 additional years of life expectancy are found for a suburban population as compared to the population in one of the cities in 1930. The coefficient for "rural county" represents 8.773 additional years of life expectancy for a population in a rural county as compared to a city population in 1930. By subtracting the coefficient for rural county from that for suburb ($9.125 - 8.773 = 0.352$), the value of 0.352 additional years of life expectancy is obtained for a suburban population in 1930 as compared to a rural population.

A second regression model, with the same variables as the one for 1930, was constructed for 1980. The characteristics of the 1980 model are given in Table 4. In this model, the constant shows that life expectancy is 69.875 years for the city populations in 1980. Compared to the city populations, the suburban populations experienced 2.125 additional years of life expectancy, whereas the populations in the rural counties experienced 1.852 additional years of life expectancy in 1980. (As in the model for 1930, the coefficients of the 1980 model were significantly different from zero ($P < .01$), and by the F-test, there are still significant area effects on life expectancy in 1980 ($P < .01$).)

Although both models indicated significant area effects on life expectancy, a comparison of the equivalent coefficients across both models showed that the effects were very different in each year (Tables 3 and 4). The expectation of life at birth for city populations in 1980 was 69.875, which is 13.375 years higher than that for city populations in 1930. Similarly, the difference in coefficients for the variable of suburb ($2.125 - 9.125 = -7$) indicates that the city populations gained seven years of additional life expectancy relative to the suburban populations between 1930 and 1980. The

TABLE 3
Multiple Regression Results for 1930

Variable	b	Standard error	t-value (b = o)	P(b = o)
Suburb*	9.125	1.83	4.98	<.01
Rural county*	8.773	1.51	5.80	<.01
(Constant)	56.50	—	—	—
		$R^2 = 0.514$		
		Standard error of estimate = 3.67		

Analysis of Variance

Source of variation	df	Sum of squares	Mean square	F-ratio	Probability
Model	2	497.26	248.6	18.5	$P < .01$
Residual	35	470.24	13.44		

*Dummy variables coded as: suburb, 1 = yes, 0 = no; rural county, 1 = yes, 0 = no.

TABLE 4
Multiple Regression Results for 1980

Variable	b	Standard error	t-value (b = o)	P(b = o)
Suburb*	2.125	0.44	4.82	<.01
Rural county*	1.852	0.36	5.09	<.01
(Constant)	69.875	—	—	—
		$R^2 = 0.467$		
		Standard error of estimate = 0.88		

Analysis of Variance

Source of Variation	df	Sum of squares	Mean squares	F-ratio	Probability
Model	2	23.48	11.92	15.3	P < .01
Residual	35	27.24	0.778		

*Dummy variables coded as: suburb, 1 = yes, 0 = no; rural county, 1 = yes, 0 = no.

difference in coefficients for the "rural county" variable indicates that relative to the rural populations, the city populations gained 6.92 additional years of life expectancy between 1930 and 1980 [(1.852 − 8.773 = −6.92)]. Finally, between 1930 and 1980 the rural county populations gained 0.079 additional years of life expectancy relative to the suburban populations [(2.125 − 1.852) − (9.125 − 8.773)} = −.079]. A "saturated" multiple regression model was constructed using both 1930 and 1980 in which year was included as a dummy variable (0 = 1930; 1 = 1980), as were variables for interaction effects between (a) year and suburb, and (b) year and rural county. When analyzed in a fixed-effects analysis of variance framework, this model indicated that the interaction effects were significant ($F = 10.80$; 2,70; $P < .01$).

The Chow Test (Chow 1960, Fisher 1970) was used to determine if the models for 1930 and 1980 were statistically different. The null hypothesis in this test was that the model for 1980 was equivalent to the one for 1930. The alternative hypothesis was that they were not equivalent. The Chow Test produced an F-ratio of 62.6 (3.70) which is significant at $P < 0.01$. Thus, we concluded that the area effects on life expectancy in 1980 were significantly different from those in 1930.

The statistical tests clearly support the argument that, while differences in longevity have narrowed between 1930 and 1980, significant variation persists among suburban, urban, and rural areas in Ohio. This implies that socioeconomic status effects persist in determining differential mortality levels because socioeconomic status is associated with geographic settlement patterns (Darroch and Marston 1971, Duncan and Duncan 1955, Stockwell 1961, 1963, Stockwell and Laidlaw 1977, Stockwell and Wicks 1984, Willie 1959).

SUMMARY

Although the life expectancy figures presented here are subject to some level of error, we are confident that it is small given the accuracy of the technique developed by Swanson and Palmore (1976), Swanson et al. (1977) and Swanson and Swanson (1977). Thus, the results of the analysis given in this paper strongly suggest that there are significant area effects on longevity in Ohio over time. Specifically, geographic variation in longevity persists among suburban, urban, and rural areas, even though life expectancy increased for all areas between 1930 and 1980, and the geographical differences narrowed over this same time period.

Since the geographical areas of suburb, city, and rural county are associated with socioeconomic status differentials (Darroch and Marston 1971, Duncan and Duncan 1955), it appears that variation in longevity is more related to individual living standards and access to health care than to public health conditions such as water purity. One implication of this is that more opportunities are needed for all Ohioans to achieve the highest possible quality of life (Ohio 1985).

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APPENDIX TABLE 1
Crude Death Rate, Percent of the Population Aged 65 Years and Over, and Total Population, Selected Major Cities, Ohio, 1930 and 1980

City	1930 CDR†	1930 P65 + %*	1930 Population††	1980 CDR†	1980 P65 + %	1980 Population††
Akron	7.85	3.06	255,040	11.32	13.48	237,177
Canton	9.72	4.50	104,906	12.89	14.41	94,730
Cincinnati	15.53	6.50	451,160	12.86	14.45	385,457
Cleveland	11.00	3.59	900,429	13.12	12.97	573,822
Columbus	15.38	5.79	290,564	8.57	8.87	564,826
Dayton	11.08	5.60	200,982	11.14	11.83	203,371
Toledo	12.66	5.12	290,718	11.14	12.50	354,635
Youngstown	10.48	3.23	170,002	12.49	14.56	115,436

*Adjusted for "age not reported"
†Mortality data: US Bureau of the Census (1934); Ohio Department of Health (1982).
††Population data: US Bureau of the Census (1943); US Bureau of the Census (1982).

APPENDIX TABLE 2

Crude Death Rate, Percent of the Population Aged 65 Years and Over, and Total Population, Selected Suburban Areas, Ohio, 1930 and 1980

Suburban area (Balance of county)*	1930 CDR†	1930 P65 + %**	1930 Population††	1980 CDR†	1980 P65 + %	1980 Population†
Summit-Akron	7.32	4.30	89,091	7.73	9.40	287,295
Stark-Canton	12.40	6.36	116,878	8.00	10.10	284,093
Hamilton-Cincinnati	6.82	6.08	138,196	7.91	9.99	487,767
Cuyahoga-Cleveland	7.05	4.62	301,026	9.38	12.71	924,578
Franklin-Columbus	10.03	6.43	70,491	6.62	8.24	304,306
Montgomery-Dayton	10.25	6.82	72,499	6.99	8.89	372,376
Lucas-Toledo	7.37	4.60	56,991	6.93	8.87	117,106
Mahoning-Youngstown	8.44	4.29	66,140	8.74	10.91	174.060

*County exclusive of city indicated
**Adjusted for "age not reported"
†See Appendix Table 1
††See Appendix Table 1

APPENDIX TABLE 3

*Crude Death Rate, Percent of the Population Aged 65 Years and Over, and Total Population, Selected Rural Counties, Ohio, 1930 and 1980**

County	1930 CDR†	1930 P65 + %**	1930 Population††	1980 CDR†	1980 P65 + %	1980 Population††
Adams	12.81	9.41	20,381	10.36	12.78	24,328
Brown	13.25	12.10	20,148	9.93	12.20	31,920
Gallia	19.26	9.21	23,050	8.31	11.75	30,098
Hardin	12.63	9.47	27,635	9.32	11.79	32,719
Harrison	10.56	10.01	18,844	10.91	13.78	18,152
Henry	9.19	8.36	22,524	8.21	12.30	28,383
Highland	14.44	11.34	25,416	10.78	14.17	33,477
Holmes	10.82	8.24	16,726	7.00	10.12	29,416
Jackson	12.66	8.54	25,040	12.29	12.87	30,592
Meigs	11.23	9.58	23,961	9.73	12.92	23,641
Mercer	10.52	8.29	25,096	9.05	10.94	38,334
Monroe	10.80	10.39	18,426	6.79	13.18	17,382
Morgan	17.89	11.22	13,583	10.53	14.33	14,241
Morrow	13.80	12.09	14,489	8.27	10.04	26,480
Noble	10.89	10.17	14,961	9.55	14.87	11,310
Paulding	9.67	9.13	15,301	8.17	9.52	21,302
Perry	9.67	7.63	31,445	9.25	11.57	31,032
Pike	12.18	7.46	13,876	9.96	13.00	22,802
Union	11.98	10.56	19,192	8.87	10.46	29,536
Vinton	12.73	9.10	10,287	9.06	12.41	11,584
Williams	11.89	10.37	24,316	8.88	11.85	36,369
Wyandot	13.24	10.15	19,036	10.11	13.40	22,651

*Selected on the basis of not being part of an SMSA or having a city with a population over 10,000.
**Adjusted for "age not reported"
†See Appendix Table 1
††See Appendix Table 1

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